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OFFLINE SIGNATURE VERIFICATION USING HU'S MOMENT AND GABOR WAVELET TRANSFORM

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ABSTRACT

The signature of a person is an important biometric attribute of a human being which can be used to authenticate human identity. However human signatures can be handled as an image and recognized using computer vision and NN techniques. With modern computers, there is need to develop fast algorithms for signature recognition. There are various approaches to signature recognition with a lot of scope of research. In this report, off-line signature verification using NN is proposed, where the signature is captured and presented to the user in an image format. Signatures are verified based on parameters extracted from the signature using various transform techniques. In our project we will use Hu's moment, Radon transform and Gabor wavelet transform. By combining this transform technique we will extract more features and will get more accurate output.

KEYWORDS: Signature Verification, Human Signatures, Feature Extraction and Classification, Verification Techniques

1. INTRODUCTION

Human signatures provide secure means for sanctioning legal documents. It is widely acceptable and collectable biometric characteristic. The problem arises when someone is trying to copy our signature and steal our identity then it could be used to make serious damage to us. Therefore, there is a need for adequate protection of our signature and it needs to be known who actually signed a document. So nowadays, automatic signature verification becomes an essential component as it particularizes in handling signatures.

1.1 Techniques for the Signature Verification

Signature verification can be grouped into two methods

Online

The online method uses a stylus and an electronic tablet connected to a computer to extract information about the signature. This method empowers dynamic information such as stroke sequence, number of strokes, pressure, acceleration, and direction of each stroke to be captured while a signature is being written [1] [2].

Offline

In the offline signature verification techniques, images of the signatures written on a paper are obtained using a

scanner or a camera; hence we have static characteristics of the signatures. The presence of person is not required at the time of verification.

Organization of the Paper

The paper is organized as follows: In Section 2, we discuss the related work. In Section 3 we describe our proposed system. In section 4 we give technical explanation of our system. In Section 5, we conclude our paper.

2. LITERATURE SURVEY

According literature survey we have notice that steps for signature verification is same. They only differ in their feature extraction and classification. Various author used various features and classifier to get better result. Following are the common steps in signature verification.

2.1 Steps in Offline Signature Verification [1] [3] [4] [5]

Offline signature verification is a pattern recognition problem and a typical pattern recognition system has the following steps

2.1.1 **Data Acquisition**: For offline signature verification system, images of the signatures are scanned using a digital scanner. Scanned images are stored digitally for offline processing.

2.1.2 **Preprocessing**: The purpose of pre-processing phase is to make signatures standard and ready for feature extraction. The pre-processing stage primarily involves; Background Elimination, Noise Reduction, Width Normalization and thinning.

2.1.3 **Feature Extraction:** The success of a signature verification system greatly depends on Feature extraction. An ideal feature extraction technique extracts a minimal feature set that maximizes interpersonal distance between signature examples of various persons while minimizing intrapersonal distance for those belonging to the same person.

2.1.4 **Comparison / Classification:** This model accepts input (feature set of the test Signature) obtained from the feature extraction process and compares it with stored feature of the reference signature and finally determines whether the given features belong to the required class of reference signature features

2.1.5 **Decision Process:** Finally the decision process evaluates the comparison process output with respect to a threshold and the signature is accepted or rejected.

2.2 Work Done by Various Authors is as Follows

M. Radmehr, S. M. Anisheh and I. Yousefian [6] propose a new offline signature recognition system based on Radon Transform, Fractal Dimension (FD) and Support Vector Machine (SVM). In the first step, the 2D Radon transformation is applied on the signature image in order to projection of the image intensity along a radial line oriented at a specific angle. In next stage, the fractal dimensions of the obtained vectors are calculated in a sliding window. The calculated fractal dimensions are fed into the SVM classifier. Approach shown in this paper seems to be effective; it could be validated on a large signature database where several types of signatures can be taken into account.

Man deep Kaur Randhawa, A. K. Sharma and R. K Sharma [7] proposed the fusion of Hu's moment invariants

and zone features extracted from signature images as input patterns. The model described in this paper successfully verifies the off-line signature with 90% accuracy.

Mohamad Hoseyn Sigari, Mohamad Reza Pourshahabi and Hamid Reza Pourreza [8] proposed a method after pre-processing, place a virtual grid on signature image and Gabor coefficients are computed on each point of grid. Next, all Gabor coefficients are fed to a layer of SVM classifiers as feature vector. The main characteristic of proposed method is independency to nation of signers.

Ashwini Pansare and Shalini Bhatia [9] uses extracted features as Maximum horizontal and vertical histogram, Center of mass , Normalized area of signature, Aspect Ratio , Tri surface feature , six fold surface feature and Transition feature which gives to train in a neural network. The correct classification rate of the system is 82.66%.

Mandeep Kaur Randhawa1 and A.K Sharma and R.K Sharma [10] cover fusion of features, named, diagonal and statistical features are extracted from 25 equal zones and are used as input patterns to test the performance of the model. The proposed system has specificity as 89% and sensitivity as 95%.

Komal Pawar, Rashmi Pawar, Nanasaheb Pote, Namrata Tarukhakar and Gopika Mane [24] proposed a method for offline signature identification using MLP neural network which uses global features: signature area, signature height-to-width ratio, horizontal and vertical centre of signature, max horizontal and max vertical histogram, number of edge points of the signature which can be extracted by image processing is used.

After analyzing these methods for offline signature verification we find that Hu's transform and Gabor wavelet transform gives unique features. In [7] Hu's moments are applied on different zones and as per our knowledge when we apply any transformations on horizontal zone on signature it will not give a proper output as most of the signature is horizontally long. So if we divide the signature horizontally it contains most of the information in middle zone only, rests of the zones are wasted. In [8] also same problem is there, in that virtual grid is placed on signature where most of the zones are empty. In order to solve the problems and extract more fine features of signature we propose a new system [6], [7], [8].

3. PROPOSED SYSTEM

In our proposed system we basically use two feature extraction technique Hu's moment invariant and Gabor wavelet transform. We first acquired signature using scanner so that we can get offline signature in digital format. After data acquisition we preprocessed our signature image to let it suitable for feature extraction and classification. In preprocessing we will do Background Elimination, Noise Reduction, Width Normalization and thinning. After that we fed our signature for feature extraction. In feature extraction we first apply Hu's moment on signature to extract features. Again on preprocessed signature apply radon transform at an angle of 0°, 45°, 90° and 135°. After these projections we will get 2D projection image; on that images again apply Hu's transform. Again on preprocessed signature to extract more fine features we segment our signature into four equal zones. And then on each zone we apply Gabor wavelet transform and Hu's transform. We apply Gabor wavelet transform at rotation angle of 0, $\pi/8$, $\pi/4$, $3\pi/8$, $\pi/2$, $5\pi/8$, $3\pi/4$, $7\pi/8$ and wavelength of 2, 4, $4\sqrt{2}$, 8, $8\sqrt{2}$.

After extracting features from signature these extracted features we will fed to the neural network classifier for training and testing.

Flow of our system is shown in following flow chart

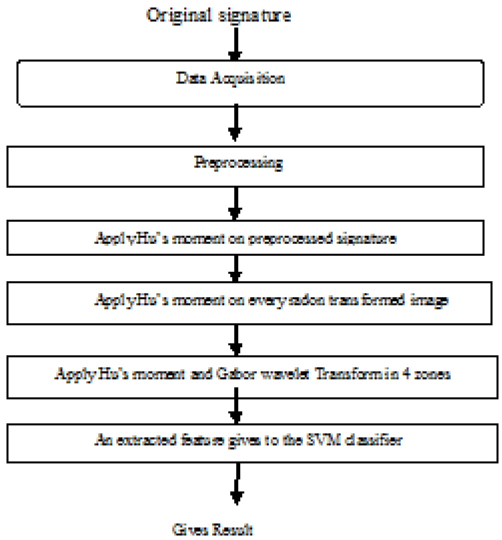

Figure 1: Flow Chart of Our Proposed System

4. TECHNICAL EXPLANATION

4.1 Data Acquisition

The signature to be processed by the system should be in proper digital image format. We need to scan the signature through optical scanner from the document for the verification purpose.

4.2 Preprocessing

The preprocessing step is applied both in training and testing phases. Signatures are scanned in gray. The purpose in this phase is to make signatures standard and ready for feature extraction. The pre-processing stage primarily involves some of the following steps: [12]

4.2.1 Normalization

Before any farther processing takes place; a noise reduction filter is applied to the binary scanned image. Figure 1 and Figure 2 shows this stage.

Figure 2: Original Image

4.2.2 Image Binarization

It allows us to reduce the amount of image information (removing colour and background), so the output image is black-white.

Figure 3: Binarized Image

4.2.3 Data Area Cropping

Morphological operation Erosion and Dilation applied to perform this step.

Figure 4: Erodated and Dilated Image

4.2.4 Edge Detection

In this procedure unnecessary signature areas are removed.

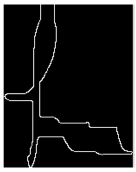

Figure 5: Edge Detected Image

4.3 Feature Extraction

4.3 .1 Hu's Moment Invariant

An essential issue in the field of pattern analysis is the recognition of objects and characters regardless of their position, size and orientation. The idea of using moments in shape recognition gained prominence when Hu (1962), derived a set of invariants using algebraic invariants [13]. They consist of groups of nonlinear centralized moment expressions. The result is a set of absolute orthogonal (i.e. rotation) moment invariants, which can be used for scale, position, and rotation invariant pattern identification [14].

In particular, Hu (1962), defines seven values, computed by normalizing central moments through order three, that are invariant to object scale, position, and orientation is as follows:

$$M_1 = (\eta_{20} + \eta_{02}),$$

$$M_2 = (\eta_{20} + \eta_{02})^2 + 4\eta_{11}^2,$$

$$M_3 = (\eta_{20} + \eta_{02})^2 + (3\eta_{21} + \eta_{03})^2,$$

$$M_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2,$$

$$M_5 = (\eta_{30} + 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} + \eta_{30})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta 122 - \eta 21 + \eta 032,$$

$$M_6 = (\eta_{20} + \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + 3\eta_{12})(\eta_{21} + \eta_{03}),$$

$$M_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] - (\eta_{30} + 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \quad (4.3.1.2)$$

We apply this moment on preprocessed signature; so that signature becomes invariant to scale, position and orientation.

4.3.2 Radon Transform

The radon transform is projections of an image matrix along specified directions. To represent an image, the radon transform takes multiple, parallel-beam projections of the image from different angles by rotating the source around the center of the image [15].

Projections can be computed along any angle. In general, the Radon transform of f(x, y) is the line integral of f parallel to the y´-axis [28].

$$\int_{-\infty}^{\infty} f(x' \cos \propto \; - y' sin \propto, x' \sin \propto + y' \cos \propto) \, dy' \qquad (4.3.2.1)$$

Where

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

Each signature is a static image and contains no dynamic information. Since the feature vectors are obtained by calculating projections at different angles, simulated time evolution is created from one feature vector to the next, where the angle is the dynamic variable [15].

For our system the projection of the 2D function $f(x, y)$ has been performed in $\alpha = 0°, 45°, 90°$ and $135°$ directions according to equation of radon transform. By using this projection 4 vectors are obtained. On this four vector we again apply Hu's moment transform to extract more features.

4.3.3 Gabor Wavelet

Gabor wavelets are the result of the multiplication of a sinusoid function by the two dimensional Gaussian function. The sinusoid signal extracts frequency information corresponding to its frequency and the Gaussian function determines the region of effects of the sinusoid signal. Therefore, Gabor wavelet operates as like as a local edge detector [8].

2-dimnesional Gabor wavelet filter in point (x, y) has five parameters and is defined as below [8] [16]:

$$w(x, y) = \exp((x'^2 + \gamma^2 y'^2) / 2\sigma^2) \cos (2\pi x'/\lambda + \varphi) \qquad (4.3.3.1)$$

x' and y' are computed using following equation :

$$x' = x \cos\theta + y \sin\theta \qquad (4.3.3.2)$$

$$y' = x \sin\theta + y \cos\theta \qquad (4.3.3.3)$$

Where,

- θ specifies the orientation of the wavelet. This parameter rotates the wavelet about its center. The orientation of the wavelets dictates the angle of the edges or bars for which the wavelet will respond. In most cases theta is a set of values from 0 to π . Values from π to 2 π are redundant due to the symmetry of the wavelet.

- λ specifies the wavelength of the cosine wave, or inversely the frequency of the wavelet.
- φ specifies the phase of the sinusoid.
- σ specifies the radius of the Gaussian. The length of the Gaussian radius, determines the size of the region that should be affected by the convolution .This parameter is usually proportional to the wavelength, such that wavelets of different size and frequency are scaled versions of each other, i.e. $\sigma = c\,\lambda$.
- γ specifies the aspect ratio of the Gaussian. In most Gabor wavelets this parameter is set to 1.

To extract features we will first segment the signature in equal four zones of size 256 *64 pixel instead of placing a virtual grid on signature because when we place virtual grid of size 9*9 it contains more number of empty zones. And as we know most of the signatures are expanded horizontally therefore for this purpose we make 4 zones vertically on signature which contains no empty zones and reduces calculations time.

And then on each zone Gabor coefficients are computed on cross point in given rotation angles and wavelengths. These Gabor coefficients form the feature vector.

In our experiment five parameters of the Gabor wavelet were determined as follows.

- θ has to cover the angles between 0 and π degree. In the proposed system θ includes 0, $\pi/8$, $\pi/4$, $3\pi/8$, $\pi/2$, $5\pi/8$, $3\pi/4$, $7\pi/8$.
- φ was set to 0 and $\pi / 2$. 0 and $\pi / 2$ refer to real and imaginary parts of the wavelet respectively.
- σ is usually proportional to the wavelength i.e. $\sigma = c\,\lambda$. In our system c was set to 3.
- γ determines the aspect ratio of the mask, that was equal to 1 in order to form a square mask.
- λ belongs to 2, 4, $4\sqrt{2}$,8,$8\sqrt{2}$

By assuming 5 wavelengths and 8 rotation angles for Gabor wavelet, there are 5x8=40 coefficients per feature point, therefore the feature vector of each signature image comprises of 4x40=160 coefficients totally. Absolute of these coefficients are the features that are fed to classifiers.

4.4 SVM Classifier

In our proposed system for signature verification, we will use Support Vector Machine (SVM) as a classifier. All the extracted features are fed into the SVM for classification. The problem that SVMs try to solve is to find an optimal hyper plane that correctly classifies data points by separating the points of two classes as much as possible. For signature verification, number of SVM classifiers is equal with number of signers. A SVM classifier is used per class that classifier output is -1 or +1. When all classifier outputs except only one classifier are -1, the class of input signature will be the corresponding class of classifier that generates +1. When the output of all classifiers are -1 or two or more classifier outputs are +1, the input signature will not belong to known classes.

Third order polynomial is selected for kernel of SVM classifiers. Increasing or decreasing the order of polynomial kernel will eventuate to lower identification rate.

5. CONCLUSIONS

The system proposed for offline signature verification will overcome the drawbacks of horizontal zoning and virtual grid. In our system we use Hu's transform, radon transform and Gabor wavelet transform. Hu's transform extract features from signature and make it invariant to translation, rotation and scaling. Radon transform gives projected image of signature at different angle. And on image applying Hu's transform gives more features at various angles. Gabor wavelet transform is applied on various angles to extract more fine features. By combining various transform technique we extract more features from signature which will be useful for classification. We will use SVM for classification. Our proposed system will give better result as it gives more fine features of signature.

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